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CYTOGENETIC SCREENING OF DIFFERENT BREEDS OF RABBIT FOR GROWTH POTENTIALS IN A WARM HUMID TROPICAL ENVIRONMENT

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TITLE PAGE

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CERTIFICATION

This is to certify that this research work was carried out by Nweke Crescent Uchenna with the registration number PG/ M.Sc./09/51391, a post-graduate student of the Department of Animal Science, Faculty of Agriculture, University of Nigeria, Nsukka. This work is original and has not been submitted in part or full for any other degree or higher degree in this or any other University.

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External Examiner Date

DEDICATION

This research work is dedicated to Almighty God for all his goodness upon my life. I also dedicate it to my dearly beloved parents Mr and Mrs Ozonweke Crescent N., my lecturers and all my friends.

ACKNOWLEDGEMENT

I wish to acknowledge God Almighty whose grace was sufficient for me during the course of this research work. I sincerely wish to appreciate all my lecturers for their unquantifiable efforts in bringing this my dream to lime light. I wish to express my profound gratitude to my supervisor Dr. Foleng H. Ndofor who gave me hope when it seemed all hope was lost. Special to me is Dr. A. E. Onyimonyi (Head of Department Animal Science), his is the man that makes things work. I thank Emeritus Prof. C. C. Nwosu, Dr. N. S. Machebe, Dr. C. C. Ogbu, and Dr. A. O. Ani for their contributions. I wish to express my immense gratitude to my parents Mr and Mrs Ozonweke Crescent N., my brothers and sisters for their spiritual and financial supports. I am not forgetting my friends whose names I cannot mention for wants of space and time. I also owe my gratitude to the University authority for the opportunity given me as a student of this noble institution of learning. May God in his infinite mercy continue to bless, protect, guide and direct your paths and finally, may He reward you with his precious gift of everlasting life.

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ABSTRACT

The study was carried out to determine the x-chromatin status of different breeds of rabbit and their crosses. The genotypes were Newzealand (NZW) x Newzealand (NZW), Dutch Black (DTB) x Dutch Black (DTB), (NZW) x DTB, and DTB x NZW. One hundred and sixty-nine offsprings from the mating were screened. Blood samples were collected with heparin sample bottles fortified with EDTA anti-coagulant via the ear veins and blood smears were made on clean glass slides. They were stained with Geimsa, rinsed in distilled water and air dried. With the aid of microscope, 200 polymorphonuclear neutrophils were examined for the presence of drumstick appendages. The result revealed that the females had the average x-chromatin status of 2.09%, 2.00%, 2.28% and 2.07% for NZW x NZW, DTB x DTB, NZW x DTB and DTB x NZW genotypes respectively while the males had the average x-chromatin status of 0.00%, 0.05% 0.00% and 0.00% for NZW x NZW, DTB x DTB, NZW x DTB and DTB x NZW genotypes respectively. These values were within the normal range of 2.00 – 12.00% for females and 0.00% - 2.00% for males. It was concluded that these animals were free from x-chromatin related physiogenetic problems. The body weight measurement of the rabbits at 4, 8, 12 and 16 weeks of age showed significant differences at ($p<0.05$) across the genotypes. The linear body measurements of males and female rabbits at 4, 8, 12, and 16 weeks of age showed significant differences at ($p<0.05$) across the genotypes. From this experiment it could be concluded that the Main crosses ((NZW) x DTB) and the Reciprocal crosses (DTB x NZW) came out better since they explored the advantages of cross breeding and it is advised that farmers should practice cross breeding of rabbits rather than breeding pure lines.

CHAPTER ONE

1.0 GENERAL INTRODUCTION

1.1 INTRODUCTION

The total world production of rabbit was estimated to range from 1,311,000 to 1,516,000 tonnes for the top 22 producer countries. From this figure, Italy had 300,000 tonnes, Russia 250,000 tonnes, France 150,000 tonnes, China 120,000 tonnes, Spain 100,000 tonnes, Indonesia 50,000 tonnes, Nigeria 50,000, tonnes, United States 35,000 tonnes and Germany 30,000 tonnes (WRP, 1990).

Rabbits are basically reared for meat, fur and cool production (TNAU, 2008). Rabbit production is very essential in improving animal protein intake in developing countries. This is because rabbit is very prolific as determined by the number of kits born alive at kindling and birth to weaning viability (Orunmuyi *et al*., 2006).

Alleviation of poverty, attainment of food security and provision of adequate nutrition are some of the millennium development goals that Nigeria has to meet. Rabbit farming can be one effective objective that can be used not only in Nigeria but also in other Africa countries (Cliford, 2009).

Advantages of rabbit farming are enormous considering the fact that they can be fed with high forage, low grain diet that is largely non-competitive with human food and they have high feed conversion efficiency. Rabbits have the potential to being in constant state of reproduction and can be mated within 24 hours of kindling. They have high growth rate attaining market weight of about 2kg at 12 weeks of age. Rabbit meat is a highly nutritious, tasty and excellent in quality. It is rich is protein, low in fat, cholesterol and sodium and thus can be recommended for cardiac patients (TNAU, 2008).

Cliford (2009) also summarized in Africa Rural Connect that Rabbits are prolific in reproduction, have high growth rate and therefore high turnover, required minimal space to keep and meager resources to maintain since they can flourish on forages that are disdained by humans.

The feeding habit of rabbit offers no appreciable competition with man. This is because it can subsist on green as basal diets. The combination of these characteristics is unique. In addition to these, rabbits have a number of other characteristics that might be advantages on subsistence farming system such as their small body size, short generation interval with relatively short gestation period average of 30-31 days. The daily weight gain is high in proportion to the body weight which gives them a rapid growth rate and sexual maturity is early. These factors result in rabbit reaching the weight of a sexually mature animal 30% faster than other animals (Ajayi *et al*., 2005) and also make rabbits suitable as meat producing small livestock in developing countries (Arijeniwa *et al*., 2000).

Ensminger (1991) identified problems facing reproduction of some farm animals to include repeat breeding, still birth, abortion, poor libido and poor semen quality. It had been documented that in the study of ruminant and human infertility that chromosomal abnormalities were the major causes of infertility and pre-natal losses of foetus. As observed by Berepubo *et al*. (1993); Omeje *et al*. (1994); and Wekhe (1998), chromosomal abnormalities lead to sub-fertility or total infertility, neo-natal deaths, repeat breeding, anoestrus, congenital defects, poor libido, poor semen quality as well as stunted growth and general poor performance in young animals.

Chromosomal abnormalities have been implicated for all these reproductive problems as observed by direct karyotyping of embryos from infertile or sub-fertile dams or sire (Long and Williams, 1980; Hares *et al*., 1980; Berepubo and Long, 1983; King and Linares, 1983; Berepubo, 1985; Murray *et al*., 1985). X-chromatin screening for the presence of drumstick appendages has proved to be one of the very many techniques for diagnosing chromosomal defects. Similar studies have revealed the presence of chromosomal abnormalities in affected farm animals (Otuma *et al*., 2005; Parkaryi *et al*., 2008; Nyeche *et al*., 2010).

In modern genetic term, X-chromatin evaluation refers to the analysis of X-chromosome only without reference to the Y-chromosome. The X-chromosome has been successfully used in domestic animals to predict the cytogenetic or genetic merit of various economically important species. These include early detection of potential sex chromosomal and developmental anomalies which considerably impair fertility and also the prediction of the growth potential of

neonates (Wekhe, 1998).The investigation of the sex chromatin in animals is based on the fact that it represents the sexual status (XX and XY) chromosomes of a particular animal.

As suggested by Bhatia and Shanker (1984), much would be saved by farmers if animals with abnormal reproductive traits were identified and culled early. Hence, the relevance of this work.

1.2 Objective of the Study

The objectives of the study are:

1. To screen rabbits for the presence of aberrant x-chromatin incidence as a way of determining their reproductive potentials.
2. To determine the genotype with highest incidence of x-chromatin appendage.
3. To determine the effect of the presence of drumstick appendage on the body weight and linear measurements of rabbit.

Justification of the Study

The application of the principle of animal breeding and genetics is one of the answers to livestock development in Nigeria. However, breeding and breed improvement can effectively take place if a large number of animal and farms are involved so that any genetic improvements are quickly spread through the participating farms (Nwosu, 1990). Achieving animal protein requirement for the masses should be the utmost concern of animal scientists and livestock farmers in developing country like Nigeria. Thus, the result of this experiment will:

i. Provide rabbit farmers with useful information on the best genotypes to consider for rapid production with a view to maximizing profit and reducing the acute shortage of animal products that has bedeviled developing countries.

ii. Reduce the high risks of producing genetically defective rabbits

CHAPTER TWO

2.0 LITERATURE REVIEW

2.1 Importance of Rabbit Production in National Economy

Livestock play significant roles in improving living condition of the poor. The purpose of keeping livestock by small-scale farmers in the southern region is for supply of farm power, food, cash income and organic fertilizer from faeces.

Rabbit production plays an important role in view of the economic risks by the spread of Asian bird flu (Otte *et al*., 2007). Perry *et al*. (2003) reported on animal species kept by small holders and their contributions to family assets.

According to the FAO (2001), backyard rabbit keeping provides additional income and supplies additional protein for poor rural and urban households with low investments and labour inputs.

2.2 Advantage of Rabbit over other livestock

According to Rastogi (2000)**,** the advantages of small-scale rabbit production are as follows

- Small size and quiet nature of rabbit makes it easy to raise them in cities, suburbs and village communities.
- Large litter size and short generation interval allows for economic returns in the short term (12-15 kits/doe/year).
- Rabbits are 2.5 and 4 times more efficient in extracting protein from forages than sheep and beef cattle.
- Rabbits can easily subsist on waste materials from the vegetable garden, family kitchen and institutional canteens/cafeterias.
- Low investment is required for establishing a small rabbitry with 3-5 breeding does.

- Meat of rabbits is an excellent, alternative source of healthy food being low in fat, salt and cholesterol.

2.3 Litter Size

Litter size is the number of kits or kittens per doe. In rabbit, a good doe usually produces 6-8 kittens per litter. Shingh (1981) reported that litter size at first and second parity appears to be constant. From second to sixth, litter size increases and will start to decrease from the seventh upwards. Rouvier (1973), however, suggested that rabbits should be culled after sixth parity for a profitable enterprise. Litter size at birth in rabbit has been known to be negatively correlated with individual rabbit weight at birth. The number varies as some factors in the womb influence the number of embryo that can develop into full kittens. An increase in litter size can reduce individual birth weight (Vicente *et al*., 1995). In selection, rabbit with large litter size is more likely to be selected. This is because the higher the little size, the higher the income to the farmer.

2.4 Body Weight

Orunmuyi *et al*. (2006) observed that parity has significant effect on weaning weight indicating that the higher the parity, the heavier the weaning weight. Such an observation had earlier been made by Prayaga and Easdy (2002). Weaning weight of rabbit was also found to be affected by litter size. The higher the litter at birth, the smaller the weaning weights of rabbit. Reddy *et al*. (2000) reported that litter size at birth and gestation length had significant effect on weaning weight of rabbit.

In experiment of selection for daily gain, direct response was always found for daily gain and indirect response for weight traits (Piles and Blasco, 2003; Moura *et al*., 1997; Estany *et al*., 1992). Indirect response was also found when the criteria were either feed conversion (Moura *et al*., 1997) or weight at market time (Larzul *et al*., 2003; Lukefahr *et al*., 1996). Akpo *et al*. (2008) reported that the mean weight of the litters at weaning was higher in the second than in the first parity (1612g Vs.2313g; p).

2.5 Growth and Growth Rate

In general, growth rate of rabbit ranges from 10 to 20g/day in the tropical regions compared to temperate countries where growth performance typically is between 35 to 40g/day. The differences may be largely due to heat stress and the quality of diets (Samkol and Lukefahr, 2008).

2.6 Sources of Feed For Rabbit

Lukefahr (1992) presented information on suitable feed sources and basic primary dietary requirements and concluded that feeds for rabbits could be obtained from a variety of sources. This include: wild, indigenous plant stands, cultivated forage plots, farm crop residues, farm surplus foods, agricultural by-products, kitchen wastes, market sources. However, wild plants may be poor in palatability and some forage may only be seasonally available.

According to Honthong Phimmasan (2005), the palatability of forage is important in rabbit production particularly in situations where the forages are expected to provide a major part of the daily nutrient intake.

2. 7 Feeds and Feeding of Rabbits

Rabbits are fed with Varieties of feed stuffs They include:

Concentrate Feeds: Maize, Guinea corn, Rice, Cassava, Sweet potato, over ripe Banana and Plantain fruits.

Protein Feeds: Soya bean meal, Fish meal, Groundnut cake, Palm kernel cake, Blood meal and cotton seed meal.

Roughages and green feeds: Elephant grass (*Pennisetum purpureum*), Guinea grass (*Panicum maximum*) etc.

Roughage and green feeds in form of grasses can be fed to rabbits so long they remain succulent and not lignified. This is because rabbits are not good digesters of roughages considering the fact that they are single-stomach animal. A good rabbit ration should therefore, contain green feeds and concentrates. It is recommended and preferably good for rabbit Farmer under semi and intensive system of management to combine maximum quantity of available forage materials with little amount of concentrates especially during the time of late pregnancy, lactation and weaning. The use of growers mash as a concentrate has been rewarding.

2.8 Feed Preference and Feeding System of Rabbit

Rabbits are very selective in their feeding behaviour and in the wild will select specific plant parts than stems, young plants materials rather than old and green rather than dry materials resulting in a diet that is high in protein and digestible energy and lower in fibre than the total plant material available. They are much more sensitive to slight change in feeds than other livestock. Sometimes, they will refuse to accept a new diet and will starve rather than accept the new feed for several days (Mc Nitt *et al*., 2000).

2.9 Water requirement For Rabbits: Rabbits are very efficient in their utilization of water. This is evident in their low-water faeces. Insufficient water will reduce feed intake and hamper the performance of rabbits and their health system. For lactating Does, provision of adequate water must be maintained for effective supply of breast milk. Therefore, it is important that Rabbits should be provided with adequate supply of fresh and clean water daily.

2.10 Cross breeding and Heterosis

Cross breeding is the mating of animals of different populations such as inbred lines, strains or breeds. In most cases, commercial hybrids are the result of a three or four-way crossing schemes, where maternal and paternal lines are crossed in order to take advantage of the expected positive heterosis in reproductive and growth traits (Balelga, 2004).

The hybrids might satisfy the need of homogeneity, healthiness and productivity requested by rational form of breeding (Corrent, 2002). Moreover, some of the most required traits in hybrids are resistance to main farm diseases and reduction of running cost particularly of feed costs that account for about 70% total cost (Larzul *et al*., 2004).

2.11 Production and Consumption of Rabbit

Lebas and Colin (1992) calculated that the world production of rabbit meat is of the order of 1.5 million tons. This would mean a per capita annual consumption of roughly 280g of rabbit meat. However, most inhabitants in many countries do not consume rabbit meat as compared to the consumption of 2.5-3kg/year is France and 4-4.5kg/year per capita is Italy.

Europe is indeed the centre of world rabbit production. The major world producers far surpass all other countries which include Italy, the common wealth of independent states countries (Russian & Ukraine), France, China and Spain.

Europe collectively accounts for 75% of total world production. China ranks second which specifically involves the central Chinese province such as Sichuan and Szechuan. Less major production areas are found in some region of Africa, Central America and South-East Asia particularly Indonesia. Rabbit is not reared in significant number in most countries of the near East.

2.12 BREEDS OF RABBIT

2.12.1 Smallest Rabbit Breeds: (Mature weight less than 1.8 kilograms)

American fuzzy: they weigh 1.4 - 1.8kilograms. They have a large, flatted "bull dog" face and lopped ears, and look somewhat like a Holland lop with long fur. They have been bred in many colours.

Britanni Petite: they weigh 0.9 – 1.1kilograms. These tiny, compact rabbit have relatively narrow heads and o trim, arched body line. Ears are medium long and erect, colours include white, black, otter, chesnut agouti and sable marten (Redmond, 2009)

Dwarf Hotot: they weigh 0.9 – 1.4 kilograms, these little rabbits have a very striking appearance. They are all white except for a ring of black around the eyes which makes them look white rabbits with black eyeliner. They have compact, rounded bodies and short, upright ears.

Himalayan: they weigh 1.1 – 2.0 kilograms. They are white rabbits with ears, nose, feet and tail coloured black, blue lilac, or chocolate. Body is long and narrow with head and rather short erect ears (Redmond, 2009)

Holland Lop: 1.3 – 1.8 kilograms. Head is slightly flattened; body is short and looks massive. They have lopped ears and a prominent crown. These popular rabbits come in many colours and have soft, fine fur.

Jersey Wooly: 1.3 – 1.6 kilograms. Body is rounded and compact. The fur on the face and upright ears is short; the rest of the body has long dense fur. They have been bred in many colours (Redmond, 2009)

Lion head: 1.4 – 1.7 kilograms. This breed originated in Belgium but has been developed in England. Body is well-rounded. Furs on body are dense and of medium length fur, 5.1 to 7.6cm long.

Mini plush Lop: 1.3 – 2.0 kilograms. The mini Rex rabbit has a compact body with narrow shoulder, short, thick, upright ears, and a Rex coat. They have been bred in many colours.

Mini Satin: 1.4 – 2.0 kilograms. Several people in USA are working to develop a small rabbit with the fur and body of 3.6 – 4.8 kilograms standard satin.

Netherland Dwarf: 0.8 – 1.1 kilograms. These rabbits have compact, rounded bodies, large heads, short necks and short erect ears. Fur is glossy and dense and comes in many colours (Redmond, 2009)

Standard Chinchilla: compact chubby-looking body of medium length. Ears are long and upright. Each hair of fur has three bands of different colours, blue at the base, pearl in the middle and black at the top.

Tan: 1.8 – 2.7 kilograms. Belly, chest, flanks, inner part of front and hind legs, triangular at nape of neck and inside of tail are tan. The rest of the fur is solid black, blue, chocolate or lilac coloured. Body is narrow and thin, medium long and racy looking. Ears are long and upright.

Velveteen Lop: 2.3 – 2.9 kilograms. Body is mandolin shaped, chest is full and rounded. The ears are lopped and measured from 35.6cm tip to tip, Fur is like that of Rex rabbit, it is being bred in several colours (C\Users\hp\ Downloads\Small Rabbit Breeds _php.m).

2.12.2 Medium Rabbit Breeds: (Mature weight between 2.7 and 4.8 kilograms).

American Sable: 3.2 – 4.5 kilogram. Nose, ears, feet and tail very fark brown, body a sepia colour. Body is medium long and full, head narrow and ears long and erected.

Belgian Hare: 2.7 – 4.3 kilograms. This rabbit has a lean racy body that looks more like a hare's than a rabbit's, large upright ears.

California: 3.6 – 4.8 kilograms, white with black ears, nose feet and tail. Full bodied with medium – length upright ears (Redmond, 2009)

English Spot: 2.7 – 3.6 kilograms. Racy body, long erect ears, butterfly mark on nose, check spot, line down the back, and side spots are coloured, body is white.

French Angora: 3.4 – 4.8 kilograms. Medium long rounded body, ears long and erect. Face, ears and front feet have short fur, rest of the body has, very long wool. Many different colours have been bred.

Giant: 3.9 – 4.3 kilograms. These rabbits are white with ruby eyes. Compact and rounded with long wool on their entire body, including tail, feet, and upright ears. This rabbit has the most wool any, because of a dense undercoat (Redmond, 2009)

Harlequin: 3.2 – 4.3 kilograms. This striking rabbit originated in France. The body is banded with two colours and the head is also two colours. It has a medium – length body with rounded hind quarters, a rounded head and long, upright ears.

Hototo: 3.6 – 5.0 kilograms. Like the dwarf Hototo, this rabbit is white with black ringing the eye. Body is rounded and thick, head is narrow, ears are medium- long and upright.

Lilac: 2.6 – right kilograms. This rabbit is dove-gray with a pinkish tint. It has a medium- sized body with a somewhat head and medium long erect ears.

Palomino: 3.6 – 4.8 kilograms. This rabbit has beautiful fur of a golden or lynx colour. Body medium – length, ears medium long and upright.

Rex: 3.2 – 4.8 kilograms. Medium – sized, well-rounded body with large erect ears. Coats are mini Rex, looking and feeling like plush velvet.

Rhinelander: 3.1 – 4.5 kilograms. This is a tri-coloured rabbit with spots of black and orange. It has a rather racy body with a narrow head and long upright ears.

Satin: 3.6 – 4.5 kilograms. The coat of this rabbit is dense, soft and has sheen to it. It has been in many colours. The body is medium- long and erect.

Stain Angora: 2.9 – 4.1 kilograms. This rabbit is long, fine, glossy-appearing wool covering all its body both the head and the upright ear (Redmond, 2009)

Silver Marten: 2.9 – 4.3 kilograms. Black, blue, chocolate or sable fur with chest, shoulder, flanks, hind quarters and limbs dotted with log with tapped guard hairs, Body is medium-sized and well-rounded ears, long and erect.(C\Users\hp\Downloads\ medium Rabbits Breeds_php.m)

2.12.3 Large Rabbit Breeds: (mature weight between 4.1 – 5.4 kilograms)

American: 4.1 – 5.4 kilograms. Slate blue or white. This rabbit has well- rounded hind quarters, narrow shoulder and long erect ears.

American Chinchilla: 4.1 – 5.4 kilograms. Medium length body with well rounded hind quarters. Base of each hair is slate blue. Intermediate band pearl, top, and is black. Ears are long and upright.

Beveren: 3.6 – 5.4 kilograms. Pear- shaped body, long erect ears, dense coat of black, blue or white.

Champahne D' Argent: 4.1 – 5.4 kilograms. This usual rabbit has a coat that changes gradually from black when very young to silver when adult. Body is medium length, full and rounded, ears are long and erect.

Cinnamon: 3.9 – 5.0 kilograms. Cinnamon coloured rabbit with gray ticking across the back. Body is medium length, well-rounded body, ears are large and erect.

Crème D' Argent: 3.6 – 5.4 kilograms. Orange – silver coloured rabbit. Medium-length rounded body. Ears are medium long and upright.

English lop: 4.1 – 5.4 kilograms. Hind quarters are rounded, shoulder and head narrow. The ears are lopped and extremely large, after measuring 24 inches from top to top (Redmond 2009).

French lop: 4.5 – 5.4 kilograms. The largest of the lop breeds. The rabbits have massive, well muscled body with wide head and thick, wide lopped. The French lop has been bred in many different colours.

Newzealand: 4.1 – 5.4 kilograms. Fur is black, red or white. Body is medium sized and well rounded. Ear are medium – long and upright. One of the rabbit breeds is often used in laboratories.

Silver Fox: 4.1 – 5.4 kilograms. Fur is black with silver which hairs throughout coat. Body is of medium, well- rounded. Head rather narrow, ears medium- long and erect (C:\Users\Downloads\Large Rabbit Breeds _php mht).

2.12.4 Giant Rabbit Breeds: (Mature weight between 12 pounds and above)

Checkered Giant: above 5.4 kilograms. White with spots of black or blue on the nose, cheek, back and hind quarters. It has a racy type body with an arch to the back. The head is relatively large, ears long and erect.

Flemish Giant: above 6.4 kilograms. Massive long body, ears long and upright. Fur is black, blue, fawn, light gray, sandy, steel or white. This rabbit takes strength to handle.

Giant Chinchilla: above 5.4 kilograms. Fur is banded slate blue, pearl and black, body is long and full, ears long and erect. **(C:\User\hp\Downloads\ Giant Rabbit Breeds _ php mht)**

2.13 COPROPHAGY

Coprophagy is the consumption of faeces by animals. Many species of animal practice coprophagy as a matter of course. Other species do not normally consume faeces, but can do it under unsual conditions. In coprophagy, many kinds of faeces are included. The animal eating faeces of orther species are called heterospecifics, while eating faeces of animals of the same species is known as alloprophagy, animals eating faeces of its own is known as autocoprophagy. The faeces are eaten after deposition or directly from anus .

2.13.1 Coprophagy in Rabbits

Rabbits do not have a complex ruminant digestive system. They extract excess amount of nutrition from grass by giving their food a second pass through the gut. Soft fecal pellets or partially digested food are extracted and consumed immediately. This is known coprophagy in rabbit. Coprophagy in rabbit is important for adequate nutritional intake of vitamin B12. During the night hours, the cecal contents move rapidly through the large bowel. These contents are extracted from the anus. These cecotrophes are known as soft faeces. These soft faeces are then consumed by the rabbits, usually directly from the anus. Coprophgy in rabbits begins from second to third week of age. A normal healthy rabbit forms two kinds of faecal pellets. They are: the hard faecal pellets which are seen on the floor of the hutch and the soft faecal pellets which are never seen. The normal faecal pellets are hard, round and are excreted during the day. The soft faecal pellets are produced in the early morning hours. Apart from being soft, they are sweet smelling and are of pea size. They contain high level of B vitamins and vitamin K. they possess twice the protein content and half the fibre of standard faeces. The ingested food of cecotrophes after been eaten again by the rabbits help to absorb previously ingested nutrients. It softens a rabbit's gut with the essential nutrients and vitamins which help in digestion of food. The habit of coprophagy was first reported by Morot in 1882 (http:/www. Pet caregt com/rabbit/copropgagy in rabit).

2.14 How to Sex Rabbit

Apart from the sex organ, there is generally little difference between the appearances of the sexes, although the buck is usually the smaller of the two and often has a broader head. In the very young rabbit, the difference in the sex organs is so slight as to be difficult for a novice to determine. The baby rabbit should be held in the left hand with the head towards the wrist. It is necessary to hold the animal gently but firmly to stop it from wriggling. The fail is held back with the index finger of the left hand and gentle pressure is exerted with both thumbs on either side of the sexual organ to expose the pinkish mucous membranes. In buck, the organ which will protrude slightly appears as a rounded tip whereas, in the doe, the organ appears slit like and will slope slightly downwards the anus. In the buck, a pair of reddish brown specks will be found near the vent, and the distance between the anus and the organ is slightly longer than found in the female. At weaning or later, the appearance of the buck's organ is circular, and the doe's organ is V-shaped. At this age and later, it is easiest to sex by balancing of animal with the middle finger

holding down the tail. The index finger and the thumb can then be used to evert the organ. Still at a later, age, the penis of the buck can be easily protruded and the scrotal sac will be visible (hppt://www.pet cargt .com/rabbits/how to sex rabbit. htm).

2.15 Effect of heat Stress on the Reproductive Potential of Rabbit.

Rabbits are very susceptible to heat stress because they have few functional sweat grand and have difficulty in eliminating excess body heat when the environmental temperature is high. Exposure of growing adult males and females to high temperature seriously affects their growth and reproductive traits and reduces the resistance to disease In female rabbits, conception rate, embryonic development, litter size, litter weight and milk production decreases and age at puberty and pre and post weaning mortality increase by exposure to heat stress. In male rabbits, testosterone concentration, spermatogenesis, temporally sterility, libido, ejaculate volume, motility, sperm concentration and total number of spermatozoa in an ejaculate decreases and sperm abnormalities and dead sperm increase by exposure to the same factor. The drastic changes that occur in rabbit's biological functional are depression in feed intake, feed efficiency and utilization,, disturbances in metabolism of water, protein, energy and mineral balances, enzymatic reactions, hormonal secretions and blood metabolites. When exposed to temperature – humidity index of thirty or more, rabbits can no longer regulate internal temperature and heat prostration sets in (FAO, 2004).

2.16 Feed Efficiencies of Common Meat Animals.

The table below shows the feed conversion efficiencies of common meat animals. It is greatest in chicken followed by pig, rabbit and sheep and least in cattle.

TABLE 1: Feed Efficiencies of Common Meat Animals

BEEF	LAMB	HOG	CHICKEN	RABBIT
2.7 – 3.6kgs feed/kg gain	1.8kgs feed/kg gain	1.1 – 1.4kgs feed/kg gain	0.9kg feed/kg gain	1.8kgs feed/kg gain

Source: (F.S.I.S, 2004)

2.17 Rabbit Meat versus the Rest

Rabbit meat apart from being recognized as white meat is highly nutritious, tasty, and excellent in quality. It is rich in protein, low in fat content, cholesterol and sodium thus can be recommended for cardiac patients.

TABLE 2: Rabbit Meat versus the Rest

Meat	Protein (%)	Fat (%)	Calories (I.U.)
Rabbit	20.80	10.25	795
Chicken	20.00	11.00	810
veal	18.80	14.00	910
Turkey	20.10	22.20	1190
Beef	16.30	28.00	1440
Lamb	15.70	27.70	1420
pork	11.90	45.00	2050

NB: This is based on 1 pound of raw meat

Source: (F.S.I.S.s, 2004).

CHAPTER THREE

3.0 MATERIALS AND METHODS

3.1 Location of study

The experiment was carried out at the rabbitry unit of the University of Nigeria Teaching and Research Farms Nsukka. Nsukka lies in the Derived Savanna Region, and is located on Longitudes $6^{0}25^{1}$ and latitude$7^{0}24^{1}$ at an altitude of 430m above sea level. The climate is a humid tropical setting with a relative humidity range of 56.01 – 103.83%. Average diurnal minimum temperature ranges from 22 – 24.7^{0}c while the average maximum temperature ranges from 33 – 37^{0}c. The annual rainfall ranges from 1680 – 1700mm (Energy Centre, UNN, 2008).

3.2 The Parental Population

The genotypes that were used for the study were the Newzealand White (NZW) and Dutch Black (DTB) procured from National Veterinary Research Institute (NVRI) Vom, Jos in plateau State, Nigeria. The acquired rabbits were subjected to quarantine test and left to acclimatise with the environment before they were introduced into the experimental units. The study was carried out from September 2012 – August 2013.

3.3 Experimental Animals and Mating

Two breeds of weaner rabbits of about 10 weeks of age were used for this study. They include: New Zealand White (NZW) and Dutch Black (DTB). Progenies of these pure breeds and their crosses were produced in one parity. The mating was as follows:

Table 3: Mating arrangements

Breeding Groups	No. of sires	No. of dams	Mating ratio
Pure line mating (NZW x NZW)	3	9	1:3
Pure line mating (DTB x DTB)	3	9	1:3
Main crosses (NZW x DTB)	3	9	1:3
Reciprocal crosses (DTB x NZW)	3	9	1:3

Three bucks of each cross were mated to nine does (Table 3) randomly sampled from the population maintained in the farm. The does were dewormed and flushed for two weeks after

which they were served immediately. Each doe was taken to its buck mate in his cage for mating in the morning hours. After a successful mating, the doe was removed and new one brought in. This procedure was repeated for three consecutive times, after which the bucks were left alone in their individual cages in case of conception failures.

3.4 Management of Experimental Animals

Under an intensive system of management, the rabbits were housed individually in wooden wire cage designed in such a way that allows easy removal of faeces, urine and feed remnants to avoid build up of odour and pathogenic diseases. They were fed forages (grasses and legumes) and concentrates between the hours of 8:00am and 9:00am; 4:00pm and 5:00pm daily. Water was given ad libitum. Does were flushed with concentrates and forage during the gestation period in order to provide enough nutrients for embryonic and foetal development. One week to the expected date of kindling, a wooden kindling box was provided for each doe in her cage to enable her get used to it. After kindling, the kits were examined and the dead ones removed from the kindling boxes. The boxes were removed five weeks after kindling. The kits were weaned at six weeks and separated by sex into different cages.

3.5 Data collection

3.5.1 Procedures for Collection of Blood samples

With the help of a laboratory assistant, sterile syringes and hypodermic needles were used to aspirate blood samples from the ear veins of the experimental animals. One sterile syringe and hypodermic needle was used per rabbit after thorough cleaning of the ears with cotton wool soaked with pure methylated spirit to avoid contamination of blood samples. Each sample collected was immediately placed into a well labeled sterile heparin sample bottle with anti-coagulant (EDTA) to avoid coagulation of blood samples. The samples were taken to the laboratory for staining and examination.

3.5.2 Procedures for Staining of Blood Samples

In the laboratory, one drop of each sample was made onto a clean glass slide with the help of Pasteur pipette and a smear was made out of it.. The smears were allowed to air-dry after which they were fixed with methanol (methyl alcohol) and allowed for at least three (3) minutes

before staining. The slides were stained with Geimsa stain (which was prepared by making a dilution of 1 in 10, that is, one volume of Geimsa stain in 9 volume of water with Buffer PH of 7.0) and allowed to act for one hour. Then, the slides were inundated with distilled water, drained and air dried at room temperature.

3.5.3 Procedures for Examination (X-chromatin Isolation)

The slides were examined under the microscope at a magnification of (x100) objective using a glass cover slip and lenzol immersion oil. Then, each slide was examined for the incidence of "drum stick appendage" on the basis of 200 Polymorphonuclear neutrophils (PMNs) screened or examined morphologically. The Polymorphonuclear neutrophils stain reddish purple with Geimsa under the microscope.

The data collected on the experimental animals were evaluated for the percentage incidence of drumstick appendages. The percentage for drumstick value was calculated as:

$$\textbf{Percentage incidence} \quad \frac{\textbf{Number of drumstick observed x 100}}{\textbf{Number of Polymorphonuclear neutrophils's examined/200}}$$

Also the body weight and length measurements of the kits were taken at 4, 8, 12, and 16 weeks of age.

3.6 Experimental Design

The experimental design was the completely randomized design with four (4) genotypes as treatment. The results obtained were subjected to ANOVA (SPSS, 2013) and significant treatment means were separated using Duncan's Multiple Range Test (Duncan, 1955).

3.6.1 Statistical Model

The statistical model adopted was

$$X_{ij} = \mu + G_i + E_{ij}$$

Where:

X_{ij} = individual observation
μ= overall mean
G_i = effect of the ith genotype (i-iv)
E_{ij} = random error

Also the body weight and linear measurements of the kits were at 4, 8, 12 and 16 weeks of age.

CHAPTER FOUR

4.0 RESULTS AND DISCUSSION

The results obtained from different genotypes and their crosses in the cross breeding experiment are presented in the appropriate tables on subsequent pages.

Table 4: The Summary of X – chromatin Evaluation Across Different Genotypes

Breeding group / genotype	**NZW x NZW**	**DTB x DTB**	**NZW x DTB**	**DTB x NZW**
Total no of male kits kindled	25.00	20.00	23.00	21.00
Total no of female kits kindled	17.00	20.00	20.00	23.00
No of males with drumstick	0.00	1.00	0.00	0.00
No of male without drumstick	25.00	19.00	23.00	21.00
No of females with drumstick	13.00	19.00	20.00	23.00
No of females without drumstick	4.00	1.00	0.00	0.00
No of cells counted	200	200	200	200
Mean percentage incidence of drumstick in males	0.00	0.05	0.00	0.00
Mean percentage incidence of drumstick in females	2.09	2.00	2.28	2.07
Percentage no of males with drumstick appendages	0.00%	5.00%	0.00%	0.00%
Percentage no of males without drumstick appendages	100%	95%	100%	100%
Percentage no of females with drumstick appendages	76.47%	95.00%	100%	100%
Percentage no of females without drumstick appendages	23.53%	5.00%	0.00%	0.00%
Range of percentage incidence of drumstick in males	0.00%	0.00 – 1.00%	0.00%	0.00%
Range of percentage incidence of drumstick in females.	0.00— 4.00%	0.00 – 4.00%	0.50 – 4.00%	1.00 – 4.00%

Key: NZW = Newzealand White, DTB = Dutch Black

The mean percentages of drumstick incidence in male rabbits (Table 4) were evaluated to be 0.00%, 0.05%, 0.00% and 0.00% in NZW x NZW, DTB x DTB, NZW x DTB and DTB x NZW respectively while, the mean percentages of drumstick incidence in female rabbits were evaluated to be 2.09%, 2.00%, 2.28% and 2.07% in NZW x NZW, DTB x DTB, NZW x DTB and DTB x NZW respectively.

The ranges of percentage incidence of drumstick observed in the study per 200 polymorphonuclear neutrophils among the females screened were between 0 – 4.0%, 0 – 4.00%, 0.50 – 4.00% and 1.00 – 4.00% in NZW x NZW, DTB x DTB, NZW x DTB and DTB x NZW respectively.These observations are in agreement with the results observed by Bhatia and Shanker (1984); Berepubo (1994); Omeje *et al*. (1994); Wekhe (1998). They observed drumstick frequency in normal bovine females to be 2.59 – 3.60% of polymorpho nuclear netrophils. Likewise, Basrur (1984) reported that normal mammalian female has X-chromatin incidence of 2 – 12%. Omeje *et al*. (1994) also confirmed this in West African Dwarf (WAD) goats where they observed incidence of drumstick of 2.83% in normal females. Nyeche *et al*. (2010) observed the drumstick incidence in normal rabbit females to be 2.78%. However, the result was different with the work done on the sex-detection in newborn rabbits using X-chromatin and PCR-SRY methods by Parkanyi *et al*. (2008). They reported the appearance of the female x-chromatin frequency to be within the range of 6.66 – 20%.

These results suggested that the females screened for drumstick appendages were free of inherent chromosome related abnormalities since the X-chromatin status lie within the normal range (2 – 12%) reported by Basrur (1984). The presence of drumstick or Barr bodies is an indication of inactivated X-chromosome (Berepubo *et al*., 2001) and this is consistent with femaleness or the presence of two X- chromosomes. In the same vein, the results of the X-chromatin evaluated for males in (table 1) were 0.00%, 0.00-1.00%, 0.00% and 0.00% in NZW x NZW, DTB x DTB, NZW x DTB and DTB x NZW respectively. These averages are in tandem with the work by Basrur (1984) where he stated that normal mammalian males have X-chromatin incidence of 0.0%- 2.0%. These results suggested that the males were from sex-chromosome related abnormalities.

These are in accordance with the findings of Bhatia and shanker, (1983) where they stated that normal fertile female animal cells are expected to show at least one drumstick appendage or Barr body in a preponderant proportion in at least 90% of its cells. X-chromatin is found in the

nucleus of the somatic cells as Barr body and in the leucocytes as drumstick. Similarly, a normal male with XY component has no “Barr body” or drumstick but has “Y body”. Therefore, any male that shows the presence of a Barr body or drumstick is considered abnormal (Berepubo, 1989; Wekhe, 1998) just as any female that does not manifest the Barr body or drumstick at all is considered abnormal (Berepubo and Umanah, 1996). Maliulo *et al*. (2011) in their experiment stated that originally, these appendages were assumed to be constituted of sex chromatin derived from heterochromatic portions of xx chromosome complex. Later, it was stated that they represented a secondary sexual characteristics and not the sex chromatin particle as seen in other cells. Although, their true nature is not certain, the drumstick appendages nevertheless allow for a sex differentiation. They are generally present in the female and either absent altogether or present in much lower numbers in the male.

It then follows that the observation of five (5) females that had no drumstick and one (1) male that had one two drumsticks may not have been affected by any form of health or management problems but have basic sex chromosomal disorder with the consequences of reproductive failure (Long and Williams, 1980; Hare *et al.,* 1980).

An analysis of the registered cases demonstrated that particular animal species may be affected by characteristic chromosomal defects, which are more common to them and that these defects are mostly inherited from the parents, although some appear spontaneously. Carriers of these abnormalities may be eliminated from breeding due to their premature death (often as an embryo) or subsequent infertility. In many cases, however, self-elimination does not occur, thus resulting in spreading of the abnormalities within the population.

The presence of abnormal females and an abnormal male (females with no presence of drumstick appendage and a male with the presence of drumstick appendage) in pure crosses experiment is suggestive of the fact that the problem could be as a result of mating between close relative otherwise known as inbreed crossing.

The adverse effect of inbreeding in animals is not in doubt. The incidences of metabolic disorders, chromosomal abnormalities and inherited disease conditions caused by harmful recessive genes increases with inbreeding. Also, performance in several characters, particularly those concerned with reproduction and survival, declines following the mating of close relatives – a condition known as inbreeding depression. These effects are largely due to an increase in the frequency of homozygous genotypes (AA and aa) at the expense of heterozygous one (Aa) which

is caused by inbreeding. It is only harmful, however, when the dominance is directional, which means that the undesirable member of a pair of gene is usually recessive. When a proportion of these harmful genes are present in the heterozygous state (Aa), the animal is protected from their adverse effect by the dominance of the normal gene; but if some of the heterozygous are replaced by homozygous recessives (aa) following inbreeding, their harmful effects become manifest. Other types of gene action are sometimes responsible for inbreeding damages, but are thought to be less important. They are: over dominance and epistatic interaction.

The Main crosses and the reciprocal crosses did not manifest any feature of abnormalities in the males and females. Being crosses of main and reciprocal genotypes, they explored the advantages of cross breeding effect which is opposite of inbreeding. These crosses are more heterozygotic than individuals in pure crosses. The opposite of inbreeding depression is heterosis or hybrid vigour and can result from the crossing of unrelated inbred animal or lines with different genetic background. In other words, what is lost through inbreeding is gained when several inbred lines are crossed randomly.

Tables 5 and 6 below show the body weight and linear measurements of the male and female rabbits. In relation with the effect of the presence of drumstick appendage isolated from the genotypes, the body weight in week 4 showed significance differences ($P< 0.05$) in the means across different genotypes. In weeks 8, 12 and 16, there were significant differences between the means of Newzealand White pure crosses and those of the Dutch Black pure crosses, main crosses and the reciprocal crosses. There was no significance difference ($P> 0.05$) between the mean body weight of Dutch Black crosses, main crosses and reciprocal crosses. This is because there were more abnormal females in the Newzealand pure crosses with the absence of drumstick appendages in their polymorphonuclear neutrophils. These abnormal females were most likely to experience reproductive problems.

There were significant differences in the linear measurements between the male and female kits across the genotypes. Their means differ significantly in weeks four, eight twelve and sixteen. This is because of the poor development in the male and female kits with chromosomal abnormalities.

Wieslaw (2009) re-echoed that the presence of chromosomal abnormalities was connected with the infertility of carriers, early mortality of embryos and newborns, heart irregularities,

under development or degeneration of reproductive organs, poor semen quality, and lower body mass increase in the offspring as well as functional and phenotypic disturbances.

Table 5: Body weight measurements of different breeding groups of rabbit (g)

Age in weeks	NZW x NZW	DTB x DTB	NZW x DTB	DTB x NZW
4	385.56±14.73^{c}	577.78±16.90^{a}	600.00±14.43^{a}	473.33±11.55^{b}
8	828.89±90.99^{b}	1211.11±53.21^{a}	1233.33±25.00^{a}	1250.00±14.43^{a}
12	1183.33±39.97^{b}	1816.67±111.80^{a}	1972.22±40.06^{a}	1888.88±29.79^{a}
16	1655.56±193.01^{b}	2505.56±56.79^{a}	2627.78±20.60^{a}	2338.89±18.22^{a}

Means on the same row with different superscripts are significantly different at ($p<0.05$).

Table 6: Body length measurements of different breeding groups of rabbit (cm)

Age in weeks	NZW x NZW	DTB x DTB	NZW x DTB	DTB x NZW
4	26.33±0.55^{a}	21.89±1.02^{b}	20.00±0.01^{bc}	19.00±0.56^{c}
8	31.44±0.59^{a}	28.56±2.00^{bc}	30.22±2.02^{ab}	27.44±0.10^{c}
12	34.66±0.33^{b}	33.33±0.18^{b}	40.56±5.00^{a}	34.00±0.63^{b}
16	39.33±3.50^{b}	39.33±0.56^{b}	44.67±0.09^{a}	39.88±1.88^{b}

Means on the same row with different superscripts are significantly different at ($p<0.05$).

CHAPTER FIVE

5.0 CONCLUSION AND RECOMMENDATION

5.1 Conclusion:

Five female rabbits from the pure crosses were screened to be free of the presence of drumstick appendages in their neutrophils while other females from the pure line matings were screened of the presence of different numbers of drumstick appendages. Those with no presence of drumstick were genetically deformed and were capable of manifesting undesirable traits during reproduction whereas those with the presence of drumstick were genetically sound and were capable of manifesting desirable traits during reproduction.

A male rabbit from the pure line was screened of the presence of drumstick appendage in its neutrophils while other males from the pure crosses were screened free of the presence of drumstick appendages. The male rabbit with the presence of drumstick was genetically deformed and was capable of manifesting undesirable traits during reproduction whereas, those with no presence of drumstick were genetically good and were capable of manifesting desirable traits during reproduction.

All males of the main crosses and the reciprocal crosses showed no presence of drumstick appendages in their neutrophils and therefore were certified genetically good for breeding programmes as they are not likely to transmit to their offspring any genetic abnormalities arising from their x–chromatin status. This is to say that the Main crosses and the Reciprocal crosses

came out better in this experiment since they explored the advantages of cross bleeding and it is advised that farmers should practice cross breeding of rabbits rather breeding pure lines.

5.2 Recommendation

I recommend the use of Newzealand White and Dutch Black for cross breeding purposes. As can be seen from the results presented in chapter four, their offspring (both male and female) manifested no abnormality in their chromatin status. Also,for Nigerian nation to achieve the very much needed food security, efforts should be made to reduce incidences of reproductive losses from abnormalities through screening of the reproductive animals before breeding them. Breeding companies and artificial insemination companies stand a better position to benefit from this programme. It is therefore, recommended that a genuine institutionalisation of functional laboratories be put in place for screening of our livestock at an affordable cost to farmer, and for proper orientation of livestock farmer on the inherent risks of using unscreened animals for breeding purposes.

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APPENDICES

Mating between Newzealand White males and females

	No of male kit	No of drumstick/male kit	No of female kit	No of drumstick/female kit	Total no of kit
$NZWM_1$ xNZWF$_1$a	1	0	2	5 0	3
x NZWF$_1$b	3	0 0 0	2	7 5	5
x NZWF$_1$c	5	0	1	7	

		0 0 0 0			6
$NZWM_2$ xNZWF_2a	4	0 0 0 0	3	6 8 6	7
x NZWF_2b	1	0	3	5 0 5	4
x NZWF_2c	3	0 0 0	_	_	3
$NZWM_3$ xNZWF_3a	4	0 0 0 0	1	4	5
x NZWF_3b	2	0 0	2	0 6	4
x NZWF_3c	2	0 0	3	1 0 6	5
Total					**42**

X-chromatin status of male Newzealand White kits from pure mating

Identification of animal (rabbit)	No of cells counted (PMNs)	No of drumstick observed	% incidence of drumstick
M_1a_1	200	0	0.0
M_1b_1	200	0	0.0
M_1b_2	200	0	0.0

M_1b_3	200	0	0.0
M_1c_1	200	0	0.0
M_1c_2	200	0	0.0
M_1c_3	200	0	0.0
M_1c_4	200	0	0.0
M_1c_5	200	0	0.0
M_2a_1	200	0	0.0
M_2a_2	200	0	0.0
M_2a_3	200	0	0.0
M_2a_4	200	0	0.0
M_2b_1	200	0	0.0
M_2c_1	200	0	0.0
M_2c_2	200	0	0.0
M_2c_3	200	0	0.0
M_3a_1	200	0	0.0
M_3a_2	200	0	0.0
M_3a_3	200	0	0.0
M_3a_4	200	0	0.0
M_3b_1	200	0	0.0
M_3b_2	200	0	0.0
M_3c_1	200	0	0.0
M_3c_2	200	0	0.0
Mean			**0.00**

X-chromatin status of female Newzealand White kits from pure mating

Identification of animal (rabbit)	No of cells counted (PMNs)	No of drumstick observed	% incidence of drumstick

F_1a_1	200	5	2.5
F_1a_2	200	0	0.0
F_1b_1	200	7	3.5
F_1b_2	200	5	2.5
F_1c_1	200	7	3.5
F_2a_1	200	6	3.0
F_2a_2	200	8	4.0
F_2a_3	200	6	3.0
F_2b_1	200	5	2.5
F_2b_2	200	0	0.0
F_2b_3	200	5	2.5
F_2c	200	_	_
F_3a_1	200	4	2.0
F_3b_1	200	0	0.0
F_3b_2	200	6	3.0
F_3c_1	200	1	0.5
F_3c_2	200	0	0.0
F_3c_3	200	6	3.0
Mean			**2.09**

Mating between Dutch Black males and females

	No of Male kit	No of drumstick/male kit	No of female kit	No of drumstick/female kit	Total no of kit
$DTBM_1$	5	0	3	2	
$xTBF_1a$		0		3	
		0		3	
		0			
		0			8
x $DTBF_1b$	1	0	4	7	
				5	
				2	
				2	5
x $DTBF_1c$	2	0	3	6	
		0		5	
				2	5
$DTBM_2$	2	0	1	5	
$xDTBF_2a$		0			3
x $DTBF_2b$	_	_	2	8	
				6	2
x $DTBF_2c$	1	0	1	4	2
$DTBM_3$	4	0	1	5	
$xDTBF_3a$		0			
		2			
		0			5
$xDTBF_3b$	_	_	3	2	
				7	
				0	3
$xDTBF_3c$	5	0	2	3	
		0		3	
		0			
		0			
		0			7
Total					**40**

X-chromatin status of male Dutch Black from pure mating

Identification of animal (rabbit)	No of cell counted (PMNs)	No of drumstick observed	% incidence of drumstick
M1a1	200	0	0.0
M1a2	200	0	0.0
M1a3	200	0	0.0
M1a4	200	0	0.0
M1a5	200	0	0.0
M1b1	200	0	0.0
M1c1	200	0	0.0
M1c2	200	0	0.0
M2a1	200	0	0.0
M2a2	200	0	0.0
M2b	–	–	–
M2c1	200	0	0.0
M3a1	200	0	0.0
M3a2	200	0	0.0
M3a3	200	2	1.0
M3a4	200	0	0.0
M3b	–	–	–
M3c1	200	0	0.0
M3c2	200	0	0.0
M3c3	200	0	0.0
M3c4	200	0	0.0
M3c5	200	0	0.0

Mean	**0.05**

X-chromatin status of female Dutch Black from pure mating

Identification of animal (rabbit)	No of cells counted (PMNs)	No of drumstick observed	% incidence of drumstick
F1a1	200	2	1.0
F1a2	200	3	1.5
F1a3	200	3	1.5
F1b1	200	7	3.5
F1b2	200	5	2.5
F1b3	200	2	1.0
F1b4	200	2	1.0
F1c1	200	6	3.0
F1c2	200	5	2.5
F1c3	200	2	1.0
F2a1	200	5	2.5
F2b1	200	8	4.0
F2b2	200	6	3.0
F2c1	200	4	2.0
F3a1	200	5	2.5
F3b1	200	2	1.0
F3b2	200	7	3.5
F3b3	200	0	0.0
F3c1	200	3	1.5

F3c2	200	3	1.0
Mean			**2.00**

Crosses between Newzealand males and Dutch Black females (Main crosses)

	No of male kit	No of drumstick/male kit	No of female kit	No of drumstick/female kit	Total no of kit
$NZWM_1$	3	0	4	8	
$xDTBF_1a$		0		2	
		0		5	
				3	7
$xDTBF_1b$	4	0	2	7	
		0		6	
		0			
		0			6
$xDTBF_1c$	1	0	3	5	
				5	
				2	4
$NZWM_2$	3	0	1	4	
$xDTBF_2a$		0			
		0			4
$xDTBF_2b$	4	0	4	3	
		0		7	
		0		5	
		0			8
$xDTBF_2c$	3	0	3	4	
		0		2	
		0		6	6
$NZWM_3$	3	0	2	7	
$xDTBF_3a$		0		1	
		0			5

$xDTBF_3b$	2	0 0	_	_	2
$xDTBF_3c$	_	_	1	5	1
Total					**42**

X-chromatin status of male kits from Newzealand and Dutch Black (Main crosses)

Identification of animal (rabbit)	No of cells counted (PMNs)	No of drumstick observed	% incidence drumstick
M_1a_1	200	0	0.0
M_1a_2	200	0	0.0
M_1a_3	200	0	0.0
M_1b_1	200	0	0.0
M_1b_2	200	0	0.0
M_1b_3	200	0	0.0
M_1b_4	200	0	0.0
M_1c_1	200	0	0.0
M_2a_1	200	0	0.0
M_2a_2	200	0	0.0
M_2a_3	200	0	0.0
M_2b_1	200	0	0.0
M_2b_2	200	0	0.0
M_2b_3	200	0	0.0

M_2b_4	200	0	0.0
M_2c_1	200	0	0.0
M_2c_2	200	0	0.0
M_2c_3	200	0	0.0
M_3a_1	200	0	0.0
M_3a_2	200	0	0.0
M_3a_3	200	0	0.0
M_3b_1	200	0	0.0
M_3b_2	200	0	0.0
M_3c	_	_	_
Mean			**0.00**

X-chromatin status of female kits from Newzealand White and Dutch Black (main crosses)

Identification of animal (rabbit)	No of cells counted (PMNs)	No of drumstick observed	% incidence of drumstick
F_1a_1	200	8	4.0
F_1a_2	200	2	1.0
F_1a_3	200	5	2.5
F_1a^4	200	3	1.5
F_1b_1	200	7	3.5
F_1b_2	200	6	3.0
F_1c_1	200	5	2.5
F_1c_2	200	5	2.5
F_1c_3	200	2	1.0
F_2a_1	200	4	2.0

F_2b_1	200	3	3.0
F_2b_2	200	7	3.5
F_2b_3	200	5	2.5
F_2b_4	200	4	2.0
F_2c_1	200	4	2.0
F_2c_2	200	2	1.0
F_2c_3	200	6	3.0
F_3a_1	200	7	3.5
F_3a_2	200	1	0.5
F_3b	_	_	_
F_3c_1	200	5	2.5
Mean			**2.28**

Crosses between Dutch Black males and Newzealand White females (Reciprocal crosses)

	No of male kit	No of drumstick/male kit	No of female kit	No of drumstick/female kit	Total no of kit
$DTBM_1$	3	0	3	2	
$xNZWF_1a$		0		2	
		0		3	6
$xNZWF_1b$	2	0	3	8	
		0		4	
				7	5
$xNZWF_1c$	2	0	2	3	
		0		6	4
$DTBM_2$	2	0	2	3	
$xNZWF_2a$		0		3	4

$xNZWF_2b$	4	0 0 0 0	2	3 5	6
$xNZWF_2c$	1	0	3	2 4 6	4
$DTBM_3$ $xNZWF_3a$	2	0 0	1	2	3
$xNZWF_3b$	2	0 0	4	5 6 5 3	6
$xNZWF_3c$	3	0 0 0	3	4 2 7	6
Total					**44**

X-chromatin status of male kits from Dutch Black and Newzealand White (Reciprocal crosses)

Identification of animal (rabbit)	No of cells counted (PMNs)	No of drumstick observed	% incidence of drumstick
M_1a_1	200	0	0.0
M_1a_2	200	0	0.0
M_1a_3	200	0	0.0
M_1b_1	200	0	0.0
M_1b_2	200	0	0.0
M_1c_1	200	0	0.0
M_1c2	200	0	0.0

M_2a_1	200	0	0.0
M_2a_2	200	0	0.0
M_2b_1	200	0	0.0
M_2b_2	200	0	0.0
M_2b_3	200	0	0.0
M_2b_4	200	0	0.0
M_2c_1	200	0	0.0
M_3a_1	200	0	0.0
M_3a_2	200	0	0.0
M_3b_1	200	0	0.0
M_3b_2	200	0	0.0
M_3c_1	200	0	0.0
M_3c_2	200	0	0.0
M_3c_3	200	0	0.0
Mean			**0.00**

X-chromatin status of female kits from Dutch Black ans Newzealand White (Reciprocal crosses)

Identification of animal (rabbit)	No of cells counted (PMNs)	No of drumstick observed	% incidence of drumstick
F1a1	200	2	1.0
F1a2	200	2	1.0
F1a3	200	3	1.5
F1b1	200	8	4.0
F1b2	200	4	2.0

F1b3	200	7	3.5
F1c1	200	3	1.5
F1c2	200	6	3.0
F2a1	200	3	1.5
F2a2	200	3	1.5
F2b1	200	3	1.5
F2b2	200	5	2.5
F2c1	200	2	1.0
F2c2	200	4	2.0
F2c3	200	6	3.0
F3a1	200	2	1.0
F3b1	200	5	2.5
F3b2	200	6	3.0
F3b3	200	5	2.5
F3b4	200	3	1.5
F3c1	200	4	2.0
F3c2	200	2	1.0
F3c3	200	7	3.5
Mean			**2.07**

ANOVA

4WEEKS BODY WEIGHT

	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	265697.222	3	88565.741	46.631	.000
Within Groups	60777.778	32	1899.309		

Total	326475.000	35			

ANOVA

8WEEKS BODY WEIGHT

	Sum of square	**df**	**Mean Square**	**F**	**Sig.**
Between Groups	**1100897.222**	**3**	**366965.741**	**13.655**	**.000**
Within Groups	**859977.778**	**32**	**26874.306**		
Total	**1960875.000**	**35**			

ANOVA

12WEEKS BODYWEIGHT

	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	3504652.778	3	1168217.593	31.297	.000
Within Groups	1194444.444	32	37326.389		
Total	4699097.222	35			

ANOVA

16WEEKS BODYWEIGHT

	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	5086875.000	3	1695625.000	18.276	.000
Within Groups	2968888.889	32	92777.778		
Total	8055763.889	35			

ANOVA

4WEEKS BODY LENGTH MEASUREMENT

	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	284.750	3	94.917	23.566	.000

Within Groups	128.889	32	4.028		
Total	413.639	35			

ANOVA

8EEKS BODY LENGTH MEASUREMENT

	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	84.528	3	28.176	6.340	.002
Within Groups	142.222	32	4.444		
Total	226.750	35			

ANOVA

12WEEKSBODY LENGTH MEASUREMENT

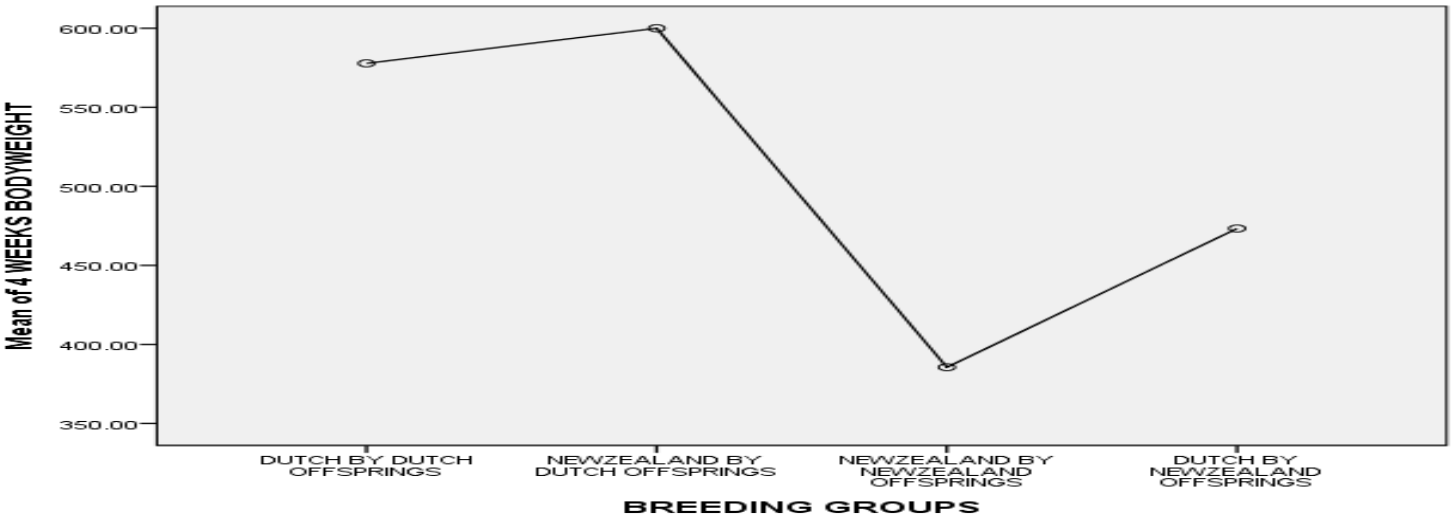
	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	298.083	3	99.361	28.847	.000
Within Groups	110.222	32	3.444		
Total	408.306	35			

ANOVA

16WEEKS BODY LENGTH MEASUREMENT

	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	180.750	3	60.250	49.577	.000
Within Groups	38.889	32	1.215		
Total	219.639	35			

Means Plots


Mean of 4 WEEKS BODYWEIGHT
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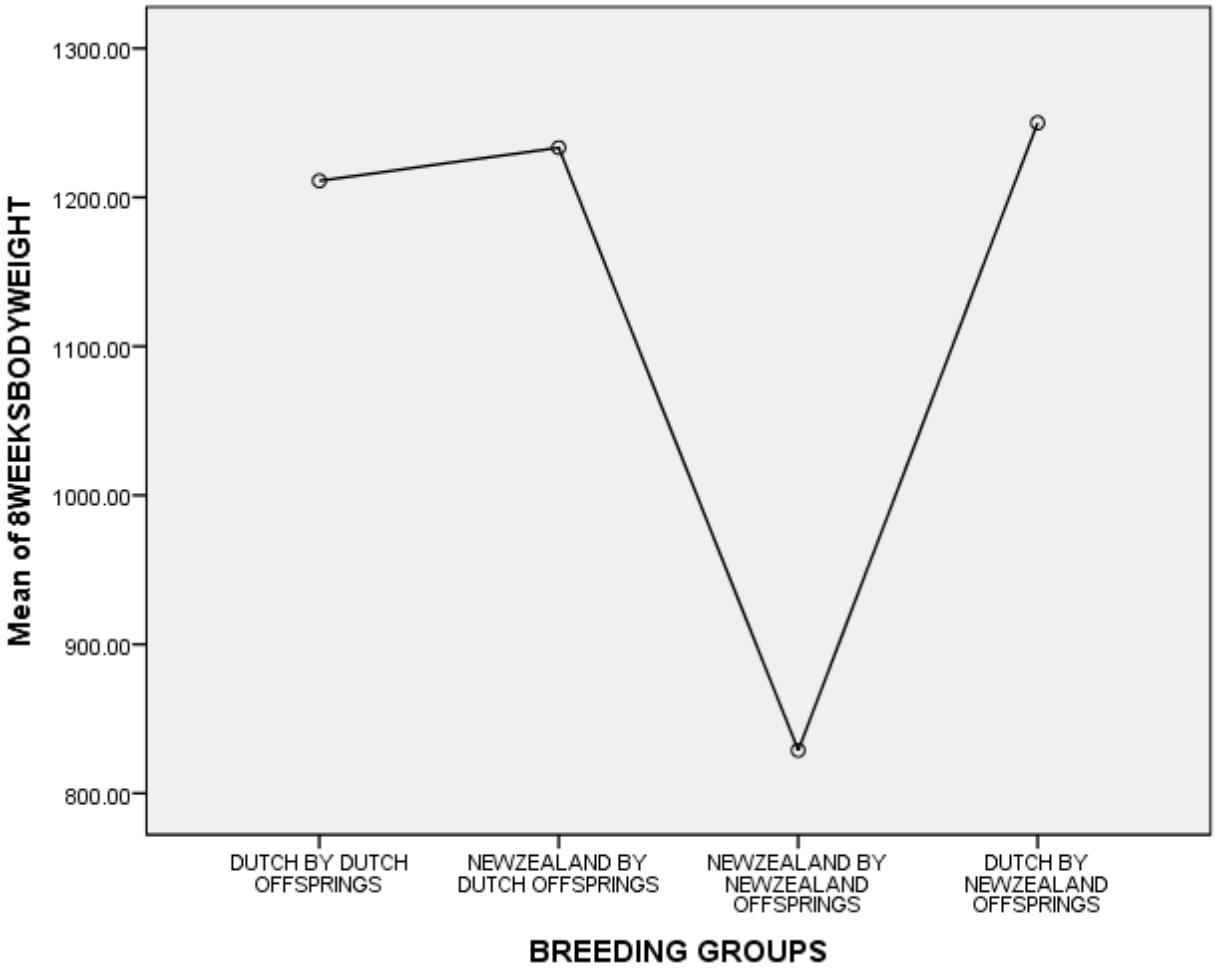
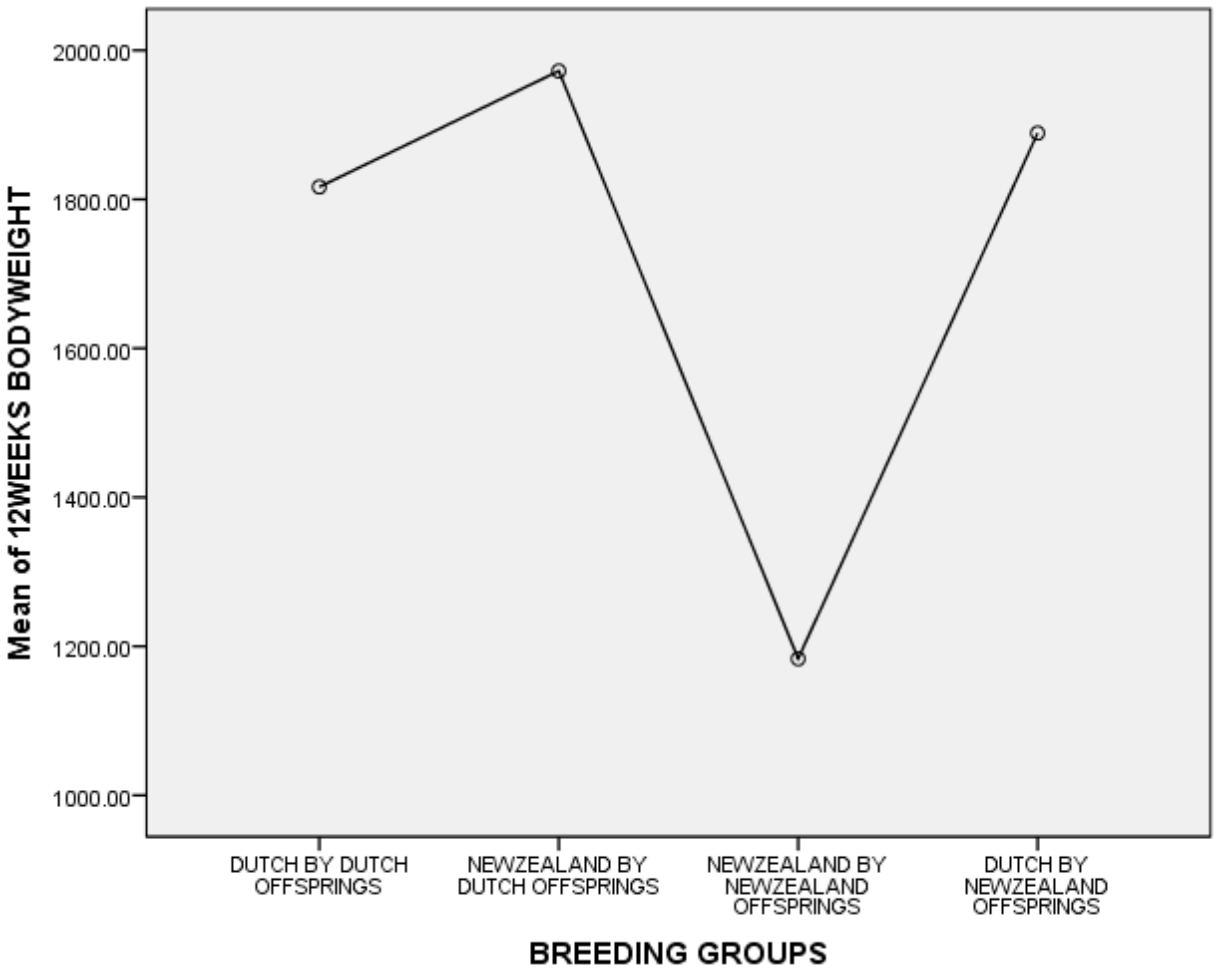
550.00
500.00
450.00
400.00
350.00
DUTCH BY DUTCH OFFSPRINGS
NEWZEALAND BY DUTCH OFFSPRINGS
NEWZEALAND BY NEWZEALAND OFFSPRINGS
DUTCH BY NEWZEALAND OFFSPRINGS
BREEDING GROUPS

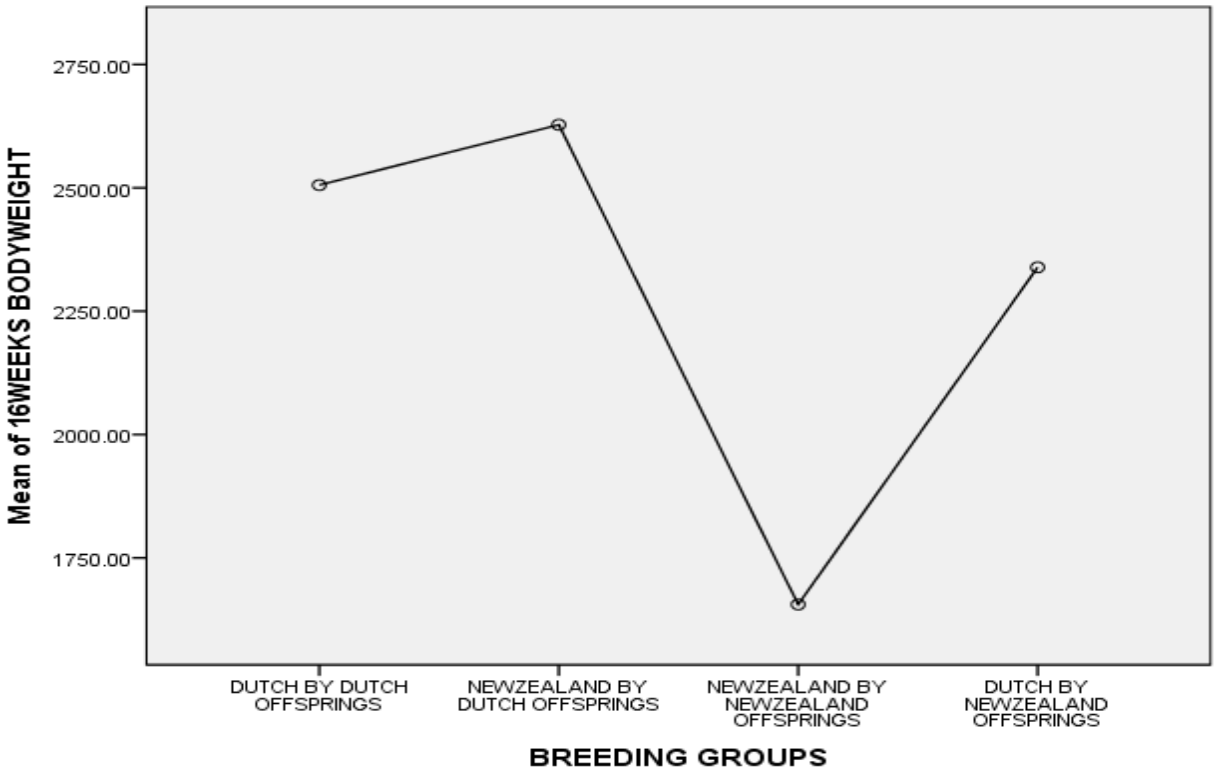
Means Plots

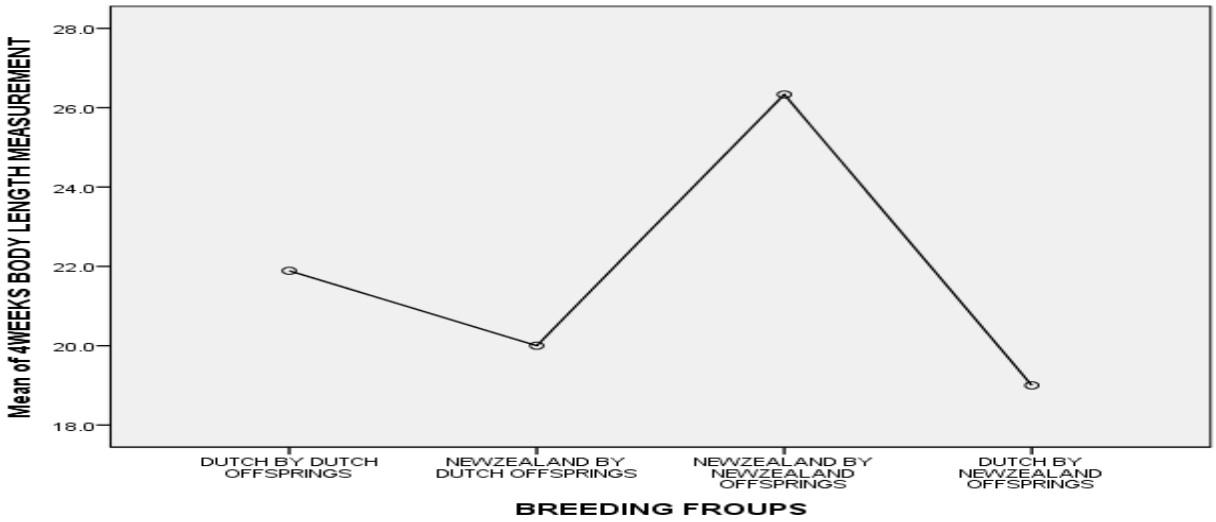

1300.00
1200.00
1100.00
1000.00
900.00
800.00
Mean of 8WEEKSBODYWEIGHT
DUTCH BY DUTCH OFFSPRINGS
NEWZEALAND BY DUTCH OFFSPRINGS
NEWZEALAND BY NEWZEALAND OFFSPRINGS
DUTCH BY NEWZEALAND OFFSPRINGS
BREEDING GROUPS

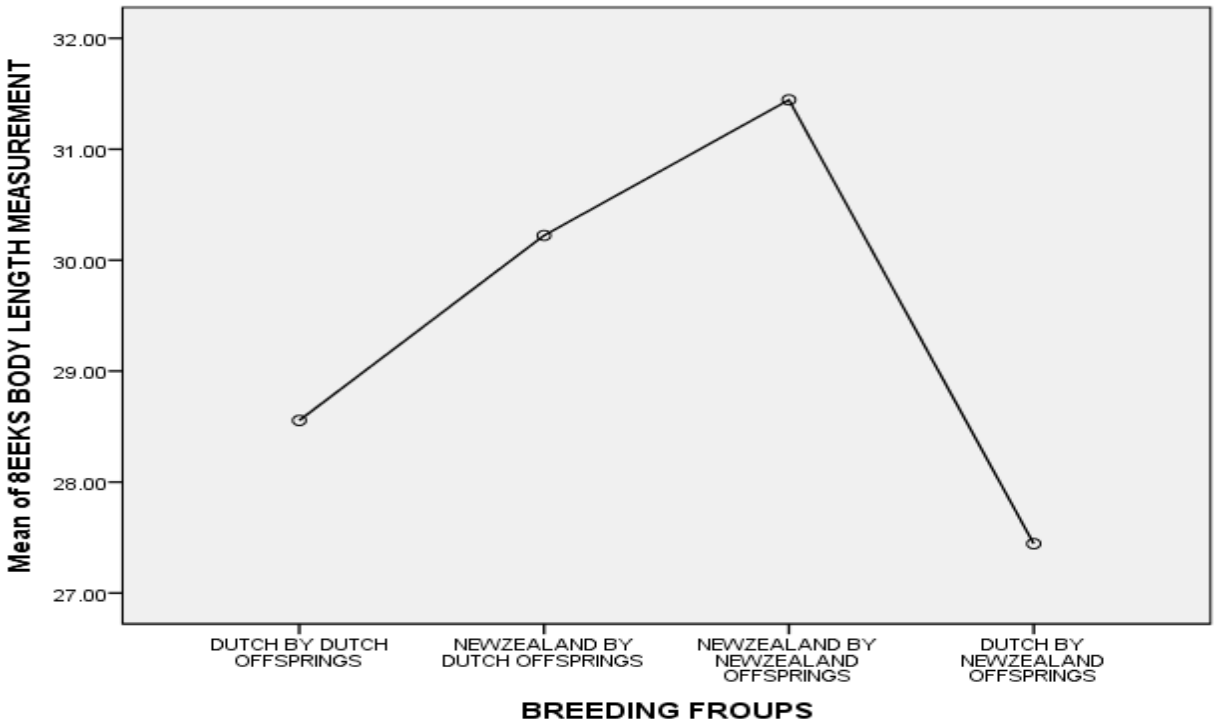
Means Plots

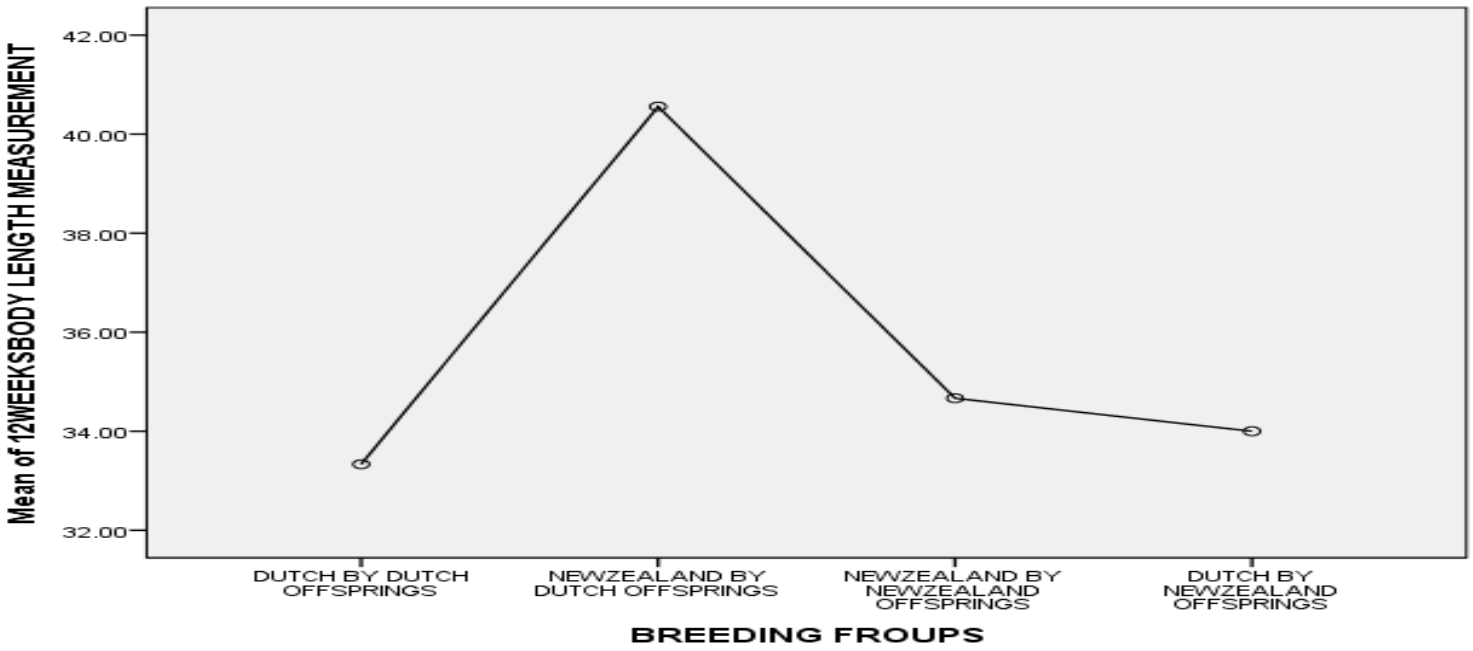

2000.00
1800.00
1600.00
1400.00
1200.00
1000.00
Mean of 12WEEKS BODYWEIGHT
DUTCH BY DUTCH OFFSPRINGS
NEWZEALAND BY DUTCH OFFSPRINGS
NEWZEALAND BY NEWZEALAND OFFSPRINGS
DUTCH BY NEWZEALAND OFFSPRINGS
BREEDING GROUPS

Means Plots

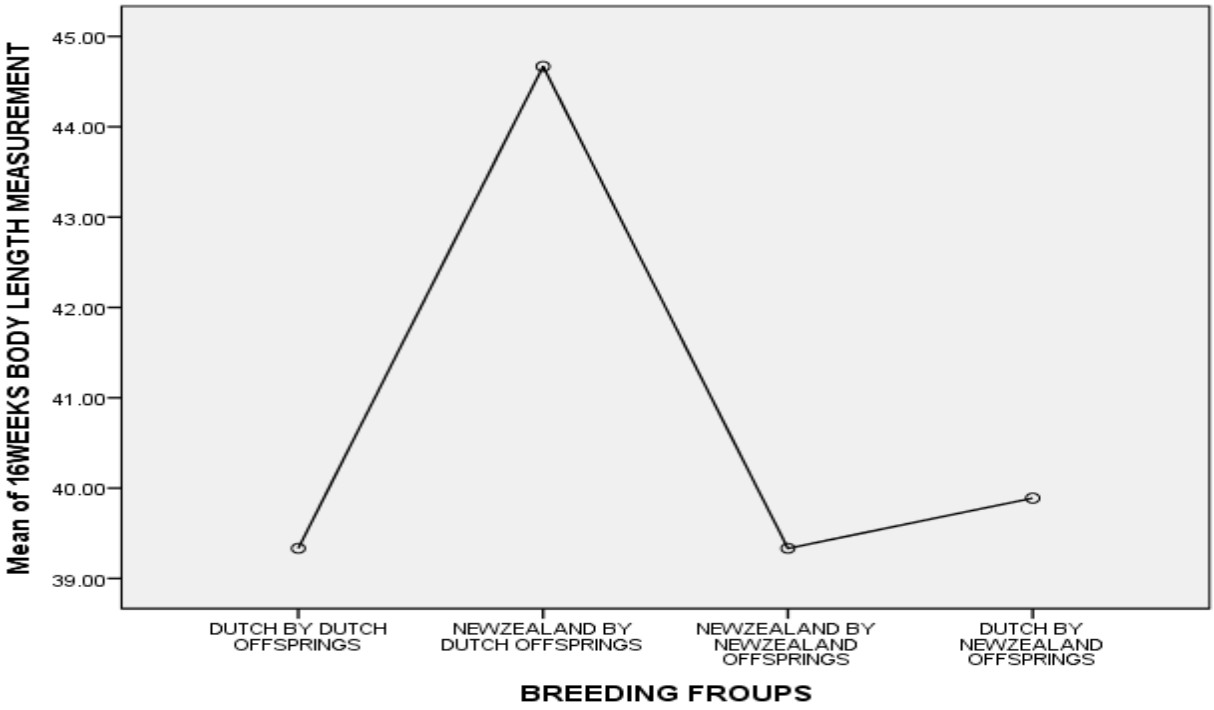

Mean of 16WEEKS BODYWEIGHT
2750.00
2500.00
2250.00
2000.00
1750.00
DUTCH BY DUTCH OFFSPRINGS
NEWZEALAND BY DUTCH OFFSPRINGS
NEWZEALAND BY NEWZEALAND OFFSPRINGS
DUTCH BY NEWZEALAND OFFSPRINGS
BREEDING GROUPS


Mean of 4WEEKS BODY LENGTH MEASUREMENT
28.0
26.0
24.0
22.0
20.0
18.0
DUTCH BY DUTCH OFFSPRINGS
NEWZEALAND BY DUTCH OFFSPRINGS
NEWZEALAND BY NEWZEALAND OFFSPRINGS
DUTCH BY NEWZEALAND OFFSPRINGS
BREEDING FROUPS


Mean of 8EEKS BODY LENGTH MEASUREMENT
32.00
31.00
30.00
29.00
28.00
27.00
DUTCH BY DUTCH OFFSPRINGS
NEWZEALAND BY DUTCH OFFSPRINGS
NEWZEALAND BY NEWZEALAND OFFSPRINGS
DUTCH BY NEWZEALAND OFFSPRINGS
BREEDING FROUPS


Mean of 12WEEKSBODY LENGTH MEASUREMENT
42.00
40.00
38.00
36.00
34.00
32.00
DUTCH BY DUTCH OFFSPRINGS
NEWZEALAND BY DUTCH OFFSPRINGS
NEWZEALAND BY NEWZEALAND OFFSPRINGS
DUTCH BY NEWZEALAND OFFSPRINGS
BREEDING FROUPS

Means Plots


Mean of 16WEEKS BODY LENGTH MEASUREMENT
45.00
44.00
43.00
42.00
41.00
40.00
39.00
DUTCH BY DUTCH OFFSPRINGS
NEWZEALAND BY DUTCH OFFSPRINGS
NEWZEALAND BY NEWZEALAND OFFSPRINGS
DUTCH BY NEWZEALAND OFFSPRINGS
BREEDING FROUPS